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ABSTRACT

Presented are the following articles: A Role for Computers in Teaching Biology; The Laboratory in General Microbiology; Rectifying the Misnomer; The "Message" of Pioneer 10: Interpretation and Role Playing for Beginning Science Students; The Project Oriented Laboratory as an Effective Teaching Method for Nonscience Majors; Environmental Education Programs in the National Park Service: An Appeal to Reason; and two abstracts from the 24th Annual AIBS Meeting, Amherst, Massachusetts. (BR)

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A ROLE FOR COMPUTERS IN TEACHING BIOLOGY

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Computers have a promising future as an instructional tool in biology. They can provide students in various applied areas with realistic quantitative experiences. Students in diverse parts of biology become decision makers whose actions can have substantial ecological, economic, and environmental impact. Current training of such students seldom provides them with experience in making decisions, particularly when they can see the consequences of various alternatives. Computers can provide a realistic simulation of that experience, but a biologist should participate in designing the computer based materials to assure their validity and relevance.

This paper examines the current status of computers in higher education and a role they could have in biological instruction. The paper also describes material currently completed and in use at New Mexico State University and elsewhere. Two simulators are described in some detail: one concerns animal breeding, the other involves population dynamics.

Computers in Higher Education

Computers permeate our existence, personal as well as academic. Although they were conceived to handle repetitive scientific calculations, their potential for doing routine clerical chores was quickly exploited. The present generation of computers have great speed, power, and reliability. Without the advent of sophisticated schemes for translating simple requests into the language computers actually use, however, this power would be inaccessible. Important aspects of these translators (called compilers and interpreters) are: (1) Their generality incorporates many options usable for instruction, but not designed primarily for that purpose. (2) Their effective utilization requires a clear understanding of both the problem being solved and the use of one of the translators.

Once you conceive an instructional use for computers, you may face two distinct problems. You may encounter difficulty getting authority to expend the needed computer time even if you have a computer on campus. Until recently, university computer centers often have allowed big users and efficiency of machine use to dominate decision making. The lack of funds has reduced time demands from the physical sciences. Further, some disciplines such as engineering have a history of using computers for instruction. Thus, there are precedents for instructional computer time.

Communication of your biological problem to a computer may pose another problem. You may be able to use computer programs developed by someone else; otherwise, you will need someone to write the necessary program. If you get to this point, take pains to clearly communicate your desires to the programmer. Computer personnel may not be experienced with the difficulties you face, either instructionally or administratively. Persistence and patience may be needed.

A Role for Computers

Computers can do repetitive and clerical tasks with great speed and precision, but they also have a creative potential in instruction. To creatively use computers in this task, we should identify relevant instructional activities and then set about building them. You may regard the computer as a dehumanizing device. Properly exploited, computer enriched instruction has the opposite effect: It allows a degree of individualization unattainable in usual lecture or laboratory settings.

Students at many levels high school, undergraduate, and graduate - can utilize computers in their learning at least three ways: (1) They can write programs to solve stated problems. (2) They can use an available program to execute tedious calculations. (3) They can gain quantitative experience. Programs for solving problems are well developed in engineering and the physical sciences. Programs to execute tedious calculations are available in statistics.

AIBS Education Review to be Available to Members Only

For two years the *AIBS Education Review* has been sent to all AIBS members and over 13,000 non-members who expressed interest in biological education. This service has been made possible in part from a grant for educational activities which will not be available after 1973. Therefore, it is necessary to limit our circulation to AIBS members effective January 1974. The quality of this publication has increased with each issue and it is a valuable service AIBS provides its members. It is copyrighted, carries referenced articles, and has a review board.

While the *Review* represents a significant part of AIBS efforts on behalf of biological educators, there are other benefits of membership. *BioScience*, the official AIBS journal, is published monthly and contains articles on a wide range of topics of interest to biology teachers. Members are also entitled to use the AIBS Placement Service.

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AIBS EDUCATION REVIEW Published by the AIBS Education Division, 3900 Wisconsin Avenue, N.W., Washington D.C. 20016. **Editorial Board:** Robert Franke, Richard B. Glazer, Stanley E. Gunstream, Charles Morlang, Jr., Newell Younggren. **Editorial Staff:** John R. Olive, Publisher, Joan G. Creager, Editor, Frances M. Lalmont, Managing Editor. Subscription free to AIBS members. Published February, April, June, October, and December. American Institute of Biological Sciences 1973. Vol. 2, No. 5, December 1973

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Computers have only begun to be used to provide quantitative experiences. Students in diverse parts of biology become decision makers, often using complex quantitative information. Decisions such as the setting of a deer season, the culling of a beef herd, the opening of a forest area to logging, the confiscation of contaminated food stuffs, etc., can have significant ecological, economic, or environmental effects. Yet most curricula give students few opportunities to make specific decisions. Such opportunities are needed if students are to receive constructive criticism before their mistakes wreak havoc.

A computer can provide a suitable environment for making such decisions. A computer program written to mimic a biological process will have several parameters. As the parameters are varied, by either the student or his instructor, a spectrum of conditions result. With specific values assigned to the parameters, the computer produces variables describing the associated biological situation, a process called simulation. The instructional value of simulation has been used extensively by the aerospace industry and the military. For example, airline pilots receive much of their training and testing in computer monitored cockpit simulators.

A simulator can be either probabilistic or deterministic. The same set of parameters always produce the same result in the deterministic case, but a new sample occurs each time in the probabilistic case. The population dynamics simulator illustrates the former while the animal breeding simulator illustrates the latter.

A simulator can operate in either batch mode or through an interactive terminal. In batch mode, the program and parameter values are taken to the computer center, usually as a punched card deck. The simulation is executed by the computer center. The completed simulation is returned later, usually as printed output. Elsewhere I have described a batch mode simulator (Urquhart 1971). Until fairly recently, only batch processing was available. Interactive terminal systems have now become economically feasible and are appearing on many campuses. Several kinds exist, but all operate on the principle that several users, each operating from a typewriter terminal, can share the computing power of a central facility. The computer responds to a user's request almost immediately. A large computer usually can execute requests much faster than users can generate them.

Such interactive terminal systems have more instructional potential than batch processing because students can initiate a simulator when they get ready, and can receive immediate diagnostic feedback on errors which would abort a batch execution. The simulator can be constructed to give each student a unique configuration of conditions.

To maximize the educational value of the experience, use of the simulator should require no knowledge of computer programming and only rudimentary information about computer access. The simulator should be able to recover from error conditions created by student input. The resulting diagnostics should be understandable, independent of the user's knowledge of computing. Creation of such a terminal-based simulator requires time, patience, and an understanding of students. Once created, it can be reused many times. Most such simulators will evolve somewhat with student and instructor experience.

Finally, the computer use described here should not be confused with programmed instruction. Programmed instruction seeks to impart facts to a student by a judiciously chosen sequence of verbal interchanges. The use advocated here provides students with an opportunity to use facts in gaining a simulation of real experience.

An Example: Animal Breeding

Some courses in animal breeding are designed to help students learn how to plan and execute breeding plans. Instructors of such courses have recognized the value of direct experience, but a laboratory in animal breeding cannot use animals with economically interesting characteristics because of lengthy gestation time and expense. Simulations provide a solution to this problem.

By 1967 several institutions had developed computer-based simulators for breeding either beef or dairy cattle, using reasonable genetic models. These used batch mode computation because terminals were not readily available. The process of saving the genetic values associated with each student's herd and later communicating his selections to the computer proved rather troublesome. Students waited two days to a week to obtain results. Procedural problems of getting students to turn in their selections, and subsequent collating of card decks absorbed substantial amounts of instructor time.

We have written a terminal-based simulator and used it successfully for three semesters. The students run it themselves at any time they choose thereby relieving the instructor of the responsibility for obtaining student selections. Since the terminal promptly gives the results of selections, students can execute enough generations to see the long term effect of their actions.

Students receive about 30 minutes of instruction on terminal usage, including a demonstration, and are given a two-page handout containing the same information. They then begin to make their own runs. About 20% of the students experience minor difficulties during their first run; thereafter, very few problems occur. In three semesters, the simulator has been used by about 150 students. Only one could not master it, apparently because he refused to read the computer's requests.

The program is usable by students with no knowledge of computing. Two simple statements (13 typewriter characters in all) start the simulator; all transactions are in conversational English. The computer requests the numbers of bulls to be used and then the numbers of cows for each bull. (Animals are numbered simply: "317" would be the 17th animal in the third generation.) Each animal number is screened as it is entered. For example, it must be in the current herd, only bulls can be entered as sires and cows as dams, a cow can be bred to only one bull in each generation, etc. The student immediately is informed of the nature of any illegal entry and asked for a suitable entry. The simulator provides numerous opportunities for the student to correct mistaken entries.

Once a student has completed his entries, the computer retrieves the genetic values of his herd, combines them according to his breeding plan, adds on random environmental effects, randomly assigns sex, randomly picks a small (5%) number of unproductive matings, and prints a report of the characteristics of the calf crop. Each line of printout gives a calf number, its sire and dam numbers, its weaning weight, yearling weight, and average daily gain. These figures are expressed as a percent of the mean of animals of the same sex. The computer then stores the genetic values of the calf crop and their parents, and turns itself off. These animals (up to 85 in number) provide the breeding pool for the next generation (up to 50 in number). Genetically desirable cows and bulls can be saved for many generations whereas the poor ones can be replaced by promising calves. Since each herd belongs to one student, only he is able to change it. The accessibility of each student's herd is protected by a security system.

The same program provides special access to the instructor. When the instructor specifies genetic means, variances, and correlations for the traits, the program creates new herds and produces an initial generation for each student. The instructor's access also lets him examine the genetic values of any of the students' herds, providing a basis for evaluating progress made by the students.

Students may execute a simulation any time the terminal system is operating, except within six hours of a previous selection. This restriction is included to encourage students to carefully plan their selections. (The terminal system operates from 8 a.m. to 8 p.m. weekdays during the semester. Evening and weekend time is sometimes available.)

Students like the idea and nature of the simulator. They generally regard it as the high point of the course. In fact, many of them suggest that greater use should be made of it.

An Example: Population Dynamics

This simulator allows a user to follow the changes a population of organisms undergoes during a cycle, ordinarily a yearly cycle. A cycle begins with reproduction and proceeds through a series of critical events with intervening periods. Critical events are short periods of time when mortality rates change for identified reasons, such as migration, hunting seasons, or overwintering. During the intervening times mortality occurs fairly evenly at lower rates.

An age distribution is followed through a cycle, experiencing age dependent reproduction and mortality. Reproduction is described by the mean number of offspring per female; conversely, mortality is specified by the probability of surviving through that stage (critical event or between critical events). In reality these probabilities do not remain constant, so in the simulator they do not remain constant. A series of (discrete) environmental qualities with associated probabilities are provided. During a simulation, the student selects the environmental quality to be used at each stage. Thus, the simulator allows the student to follow an age and environmentally dependent population through many generations.

The simulator allows a user to specify many circumstances of the population. Because of its flexibility, it has been used both in research and in teaching. The simulator has been used as an integral part of the instruction in an advanced wildlife management class for two semesters. Parameters have been set to mimic white tailed deer populations. Five environmental qualities represent very good to very bad for reproduction, summer survival, and overwintering. Hunting is the single critical event and may be specified as: (1) light hunt, male only; (2) medium hunt, male only; (3) heavy hunt, male only; (4) light hunt, female and medium hunt, male; and (5) medium hunt, female and heavy hunt, male.

Early in the term students were given all of the probabilities and associated specifications. They experimented with various situations. For example, they ran the simulator for ten years, trying to keep the population size constant. By varying the environmental quality at every stage, they effectively changed the impact of weather and predation as desired. Students quickly learned that they had little grasp of the relationships between hunting, harvest, and age-dependent reproduction. One student's population doubled even though he thought that he was "hitting it awfully hard." Students had great latitude for experimentation. Since they could choose from more than 10^{23} distinct sets of environmental quality configurations, they had to understand the impact of their actions to maintain a stable population.

In practice, a wildlife manager influences little more than the length of the hunting season. Thus, as part of their final examination, these students were assigned specific values for environmental quality, summer survival, and winter survival. They managed the type of hunting season for 15 years to achieve a specified size, age, and sex composition for the population. This gave more than 10^{10} choices of management strategies. With the knowledge they had acquired, most of the students approximated the specified conditions with only a modest amount of experimentation.

With very little effort, students learned to use the simulator. Their attitudes were very favorable toward both the simulator and its impact on their learning. In fact, they felt that the simulator enabled them to understand population dynamics in a way that could not have been accomplished by other means.

Availability of these Materials

These simulators were coded in APL (A Programming Language) because it provided the needed interactive capability and was available here at New Mexico State University. These simulators (as well as our expansions of STATPACK) are available from the Department of Experimental Statistics, Box 3130, New Mexico State University, Las Cruces, New Mexico 88003. They are available to educational institutions at the cost of reproduction. Programs are presently adapted to the IBM 360 65 with a 72K core. The population dynamics simulator will execute in standard APL using 36K workspaces. The animal breeding simulator will handle 35 herds per account number in 72K workspaces; an earlier version handled only ten in 36K workspaces. Additional information about the programs is available from the author.

Acknowledgments

Several people have made valuable contributions to the project reported here. The animal breeding simulator was used by B.J. Rankin's class; B. Wile helped write it. The population dynamics simulator was used by V.W. Howard's class; K.A. Green helped write it. T.H. Puckett provided technical assistance on computing matters.

Reference

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THE LABORATORY IN GENERAL MICROBIOLOGY: RECTIFYING THE MISNOMER

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Introduction

There are many microbiologists studying a few organisms but few microbiologists are studying many organisms. This trend is reflected in many introductory courses where one bacteria, *Escherichia coli*, is included in more than 50% of the laboratory periods of many syllabi. Especially now, when interrelationships among living organisms require elucidation, the obvious advantages of such specialization are overbalanced by the potentially narrowed student that is produced. Thus, this paper emphasizes the need to recouple microbiology, certainly at the introductory level, to the diversity of biology and focuses on several experimental designs that begin to transform "E. coliology I" into a true general microbiology curriculum.

Laboratory manuals that are used in introductory microbiology programs cover, at most, four to ten orders of bacteria. One can double the number of orders of bacteria to which the student is exposed by modifying one existing and widely used experiment, namely the Gram stain, and by adding an additional procedure on the morphogenesis of Myxobacter. Added costs are minimal and the slight increase in time that an instructor or lab assistant spends in preparation brings more than commensurate awareness to the student. Each of these experiments can be implemented with the existing apparatus found in most laboratories. The three strains of bacteria used in these studies can be purchased from the American Type Culture Collection at a total cost of $50.00 (American Type Culture Collection Catalogue of Strains, 1972), or if budget requirements demand, from the author as a gift.

The Gram Stain

In many general microbiology laboratories, there is a week or two allotted to introducing the student to the fundamental tools and techniques of the discipline. This, especially in microbiology, is more than a period of familiarization; it is one of reorientation from the visible to the invisible. Therefore, it is not sufficient to demonstrate the uses of costly equipment like the microscope and unfamiliar supplies like culture needles. We have found that one must rigorously impress the novice with the ubiquity of microorganisms and prove that though individually invisible to the unaided eye they can be manipulated and studied. This is a difficult period that requires perseverance and trust from the student and patience from the instructor. After this apprenticeship, when the student's mind is opened and the hand is steadied, one can begin to develop the receptive class.

Usually the Gram stain is introduced at this time mainly because it is invaluable in the identification of bacteria. Often this exercise has a dual purpose:

a) practice of procedure.
b) familiarity with the comparative morphology of the eubacteria.

When the same genus of organism is stained by each student only the former purpose is achieved. Most procedures, however, call for the staining of from three to five genera (Table 1).

It is apparent that among the Eubacteriales, the Gram positive cocci and rods are included, as are the Gram negative rods. With one exception, the Gram negative cocci are omitted. Of the other orders of bacteria, the Pseudomonadales and the Actinomycetales are infrequently studied. Yeasts are sometimes chosen to represent the eucaryotic protists.

Thus, to fulfill the second objective of this exercise most procedures call for about four genera of bacteria to be stained, most of them belonging to the Order Eubacteriales. Yet, we have found that although the same student will later complete the Gram stain in 15 minutes, the novice requires one hour to complete the procedure and observe the specimen (usually several attempts are necessary). For this reason, it is difficult for the average undergraduate to make more than two acceptable Gram stains during the first exposure. Therefore we have found that this exercise is best handled by dividing the class, each student gaining practice by staining and observing two organisms (or four organisms, two per slide), and learning comparative morphology by observing the different organisms his partners have stained.

When these team efforts proved to be valuable learning aids (considering time limits imposed on all instruction) we expanded the exercise. At first, the aim was to study the morphology of the eubacteria and we included Gram positive and negative cocci and Gram positive and negative rods. Added later were two members of the Pseudomonadales, *Vibrio* and *Spirillum*. These additions effectively proved that bacteria come in shapes other than cocci and rods, namely short commas and spirals.

In a pilot study, two more organisms were added to the exercise (the students were working in groups of four). Representatives of the Orders Hyphomicrobiales and Caryophanales were chosen.

Hyphomicrobia are widely distributed in freshwater, marine, and soil habitats. They have been isolated from shellfish, human nasopharynx, and activated sludge samples. They are aerobic and many species oxidize one-carbon compounds such as urea, methanol, methylamine, and potassium cyanide. Of primary concern in the Gram stain exercise is the unique morphology and morphogenic cycle (Fig. 1) of these procaryotes.

A small, non-motile swarmer cell about 0.5 μm in diameter matures into an ovoid cell, measuring 0.5 by 1.0 μm. This cell grows a stalk (hypha) about 0.3 μm wide and from 1.0 to 4.0 microns long. The stalk is just thick enough to be seen with a student oil immersion lens and success in viewing it provides a good test of one's ability to stain and focus the microscope correctly. Through the tip of a growing hypha, a bud is formed which grows a single flagellum. Completing the cycle, the bud separates from the parent, swims away (later to differentiate into a stalked cell itself), while the mother cell continues to generate more buds. All morphological forms are Gram negative.

Hyphomicrobium neptunium ATCC 15444, is the species most easily cultivated. It can be grown in Marine Broth (Difco) at 37°C. Costs can be reduced by using 30% of the recommended concentration. We have found, in fact, that better yields are obtained at 30% than at 100% of the suggested formula. The generation time at either concentration is about 2.5 hours. A 15 hour culture (in the late logarithmic phase of growth) contains about 60% stalked cells, 30% buds (one half of these being motile at room temperature), and 10% of the other morphological forms in approximately equal proportions. Alternatively, a proportion of two buds for each stalked form can be obtained by preparing lawns of the organism on Marine Agar (Difco), incubating these at 37° C for 40 hours and then refrigerating for 12 hours (Blackman and Weiner 1973).

The Caryophanales, found in fresh water, provide an interesting contrast. Members of this procaryotic order are about 30 μm (occasionally 200 μm) long by 3 μm wide (Breed et al. 1957). These organisms (trichomes) consist of many disk-like cells enclosed in a continuous wall and divided by internal septa. Each living cell contains a prominent disk-shaped nucleus. In hanging drop preparations, *Caryophanon* are highly motile and the organisms, being large and peritrichously flagellated,

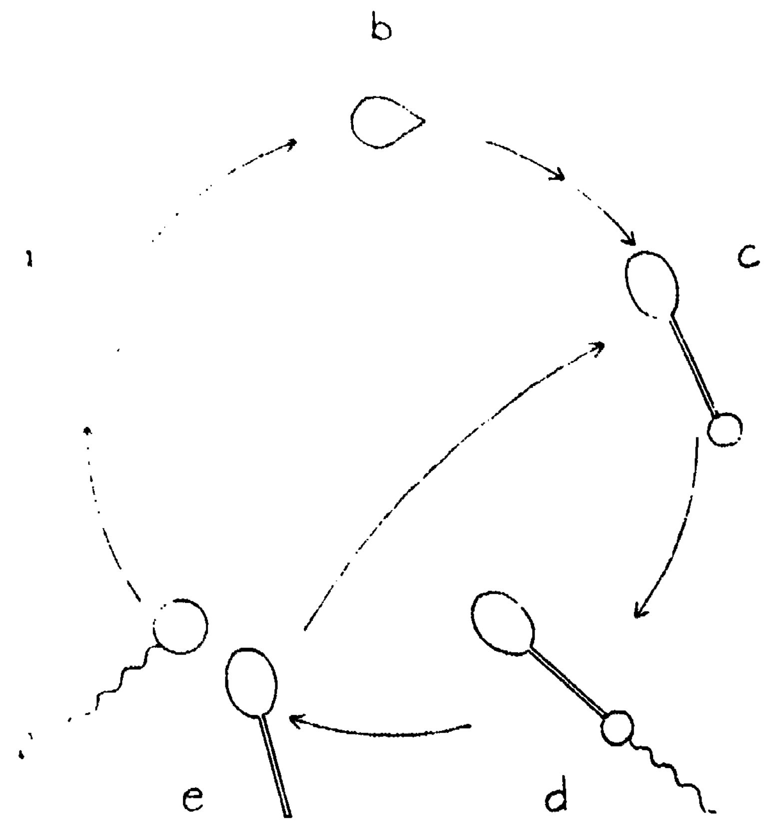

Fig. 1. Life cycle of *Hyphomicrobium*. Morphological forms: a) non-motile swarmer; b) mature cell; c) stalked cell with bud; d) stalked cell with flagellated bud; e) stalked cell; f) motile swarmer.

Table 1.

The Gram Stain: Examples of organisms suggested in a sample of six laboratory manuals suitable for use in general microbiology courses

Laboratory Manual (Senior Author)	Organisms Stained: Gram Positive Rods	Gram Negative Rods	Gram Positive Cocci	Gram Negative Cocci	Other	Total Number
Bartholomew 1967	*Bacillus subtilis*	*Escherichia coli*	*Staphylococcus aureus*		"Unknown" organisms	5*
Benson 1973	*Bacillus megaterium*	*Pseudomonas aeruginosa*	*Staphylococcus aureus*		*Mycobacterium smegmatis*	4
Bradshaw 1973		*Escherichia coli*	*Staphylococcus epidermidis*		*Saccharomyces cerevisiae*	3
Pelczar 1972	*Bacillus cereus*	*Escherichia coli*	*Staphylococcus aureus*	*Neisseria perflava*	Organisms in gum scrapings	5
Seeley 1972	*Bacillus cereus*	*Escherichia coli*	*Streptococcus faecalis* *Sarcina lutea*			4
Swatek 1969	*Bacillus subtilis*	*Escherichia coli*	*Staphylococcus aureus*		*Saccharomyces cerevisiae*	4

***** *E. coli* and *S. aureus* are mixed and stained. *S. aureus* is stained by up to five modifications of the technique. *B. subtilis* is "crushed" and then stained. Two "unknown" organisms are stained and identified by the student. A subsequent exercise deals with comparative morphology, by making use of demonstration slides.

are also good subjects for flagella stains. They are Gram variable and aerobic.

Caryophanon latum, ATCC 15219, can be cultivated and maintained on agar slants on a medium consisting of 4 grams yeast extract (Difco), 5 grams peptone (Difco), 2 grams of sodium acetate, and 1.5 grams bacto-agar (Difco) dissolved in 100 ml. of water. Colonies appear in 8 hours at 30°C at a pH of 7.7.

By adding these two organisms to the Gram stain exercise, we found that the students not only learned to make an important differential stain and learned some of the shapes of bacteria, but perhaps most significantly came to appreciate the complexity and variation of some of the simplest living things the procaryotes. With this, the laboratory became more than a vehicle in which applied procedures were mastered; it became a time when concepts took root. To cite one example, I found that many students enrolled in microbiology with the notion that all bacteria are the same size invisible. Upon leaving a laboratory having made Gram stains of the Eubacteriales, that same misconception remained. Those randomly chosen students who stained and observed *Hyphomicrobium* and *Caryophanon* side by side (the latter being up to 400 X larger) scored significantly better on questions pertaining to size and diversity of bacteria than those who relied solely on their texts and lecture notes.

Procaryotic Morphogenesis

Another interesting order of bacteria rarely, if ever, included in a basic microbiology laboratory is Myxobacteriales. Members of this order thrive in the soil where they play a prominent role in the carbon cycle, transforming compounds that are not readily decomposed such as cellulose, chitin, and bacterial cell walls into usable nutrients. Commonly, *Myxobacter* lyses and feeds on other bacteria. Morphogenically, *Myxobacter* are unique and their life cycle is considered most complex among the procaryotes. The vegetative rod-shaped cells divide by binary fission and move by gliding along surfaces, leaving a trail of slime. Other cells commonly follow in the wake of their predecessors. When the nutrient supply of amino acids becomes depleted, the vegetative cells aggregate forming a heap. This mound begins to differentiate into a head comprised of many cells and a stalk composed predominantly of slime. A large capsule may form around the head of the fruiting body while the cells undergo metamorphosis in yxospores. The myxospore is spherical and relatively it to harsh environmental conditions. The fruiting body is ..ten brightly pigmented and visible without the aid of a microscope. When the nutrient supply is reestablished, the spores germinate into vegetative cells and the cycle begins anew.

Th.se attributes suggest a number of fascinating experimental designs. Brock (1970) describes a method for the isolation of myxobacter, allowing the student to observe its predatory tendencies, gliding movement, and life cycle in the process. It is also possible to work with a captive strain and observe a controlled pattern of procaryotic morphogenesis.

Myxococcus xanthus, ATCC 25232, in the vegetative form is a Gram negative rod about 5.0 μm long. The Gram negative microcysts are 2.0 μm in diameter. The spherical, yellow orange to bright orange fruiting bodies are round structures, up to 400 μm in diameter when mature (Breed et al. 1957). The vegetative organism is cultivated and maintained on slants prepared by dissolving 20 grams of Casitone (Difco), 1 gram of $MgSO_4 \cdot 7H_2O$ and 15 grams of agar in 1 liter of 0.01 M K_2HPO_4 KH_2PO_4 buffer at pH 7.2 (Dworkin 1962). *Myx-*

Table 2.

Observations of some characteristics of bacteria in several published laboratory formats versus similar observations with suggested supplemental exercises

Characteristics of the Bacteria	Observations from laboratory syllabi that exclude experiments on members of the Orders: *Caryophanales, Hyphomicrobiales, Myxobacteriales*	Additional observations from laboratory syllabi augmented with experiments on members of the orders: *Caryophanales, Hyphomicrobiales, Myxobacteriales*
Size Range	10 fold	200 fold
Morphology	cocci rods, spirals	stalked, septated
Motility	by flagella	by gliding
Mode of Reproduction	binary (transverse) fission	budding
Cell-Cell Interaction (Cooperation)	No	Yes
Multiphasic Life Cycles	No	Yes
Nutrition	Inorganic and organic "nutrients"	Toxic and recalcitrant molecules; predatory
Spores	Endospores	Myxospores

ococcus xanthus is aerobic, has a temperature optimum of 30°C and a pH range of 7.0-7.8.

Fruiting body formation can be induced on a medium prepared by autoclaving (1.5 hr.) 10^8 to 10^9 *Escherichia coli*/ml suspended in distilled water containing 2% agar (Dworkin 1962). Optimal success in inducing myxospores depends on starvation of the vegetative cell inoculum (Dworkin 1963). Therefore, in preparation for this exercise, the instructor removes the vegetative cells from a heavily inoculated Casitone agar slant and places them, overnight, in 100 ml of a buffer consisting of 0.1% $MgSO_4$ and 0.01 M K_2HPO_4 - KH_2PO_4.

During the laboratory period each member of the class drops 0.1 ml of the starved suspension onto the center of a Petri plate containing the Casitone medium and another 0.1 ml onto one containing the *E. coli* medium.

The following laboratory period, the student can observe colonial morphology with the unaided eye and under the low power objective of the microscope. The colonies on the Casitone agar are about 1 cm in diameter while the fruiting bodies that form on the *E. coli* agar are less than one-tenth this size and are round and raised. Slime trails should be in evidence on both media. The student can make side by side Gram stains of the vegetative cell from the colony and of the myxospore from the fruiting body. This exercise takes 5 minutes during one laboratory period and about one hour of the second period, depending upon the scrutiny of the observation. If time is a critical factor, the plates and slides can be prepared as a demonstration.

This exercise shows that the simplest of cells can cooperate to benefit the species and that this cooperation and subsequent differentiation is induced by environmental stimuli. Furthermore, molecular controls governing the morphogenesis of *Myxococcus xanthus* are being investigated and the student becomes acquainted with an organism that may yield significant insights into the mechanisms of biological modulation.

Eucaryotic Protists

Commonly, general microbiology laboratory curricula devote several laboratory periods to descriptive characteristics of the algae, fungi, and protozoa. We replace and supplement these with exercises that point out the dynamic aspects of these organisms. While I strongly favor this approach, descriptions of such procedures are beyond the scope of this article. I cite two examples, however. Our students observe *Euglena* lose their chloroplast when deprived of light. S. Bartnicki-Garcia (1972) outlines a procedure for cultivating *Mucor rouxii* so that the mycelial and yeast phases can be selectively induced. These exercises, like the aforementioned ones involving the procaryotes, foster the concept of relatedness among living things. In these cases, we show that there is a link between the algae and protozoa, between "true fungi" and the yeasts.

Discussion

Bacteria are not merely homogeneous entities that derive significance because they cause disease, are involved in the production of foods, and are indicators of pollution, but also, significantly, they are a diverse group of morphologically complex organisms that share ecosystems and many fundamental life processes with the eucaryotes. In unifying bacteriology with biology, these generalizations can be made:

1. Algae have biphasic life cycles consisting of sessile and motile stages. So do the procaryotic *Hyphomicrobium*.

2. Slime molds cooperate to form fruiting bodies. So do the procaryotic *Myxobacter*. (Seeley and Denmark [1972] present a valuable experiment on *Dictyostelium discoidium*, a cellular slime mold).

If these are examples of convergent evolution, then the survival advantages of these life cycles are underscored; if not, then (at least) a behavioral thread connecting the procaryotes with the eucaryotes is woven. Thus, exercises of this nature stimulate discussion and inquiry at a time when relationships among flora, fauna, and their habitats are looming ever more significant.

Summary

When one adds three species of bacteria, representing three Orders, to existing formats, new relationships among organisms become apparent to the student in the general microbiology laboratory (Table 2).

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THE "MESSAGE" OF PIONEER 10: INTERPRETATION AND ROLE-PLAYING FOR BEGINNING SCIENCE STUDENTS

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Current scientific literature can be a great source of interesting and enlightening experiments in the beginning science laboratory. Since the research is new and at the forefront of scientific endeavor, it offers a refreshing change from the more classical frog dissection and microscope drawing. Students may encounter fresh and relevant problem-solving in actual situations. Our effectiveness as science educators depends on our providing these situations for students.

The exercise described here is based on an article by Sagan, Sagan, and Drake (1972). The article describes the engraved message sent aboard the Pioneer 10 spacecraft launched on a mission to explore Jupiter. Since the spacecraft will leave our solar system, scientists felt that it should carry a message to possible finders concerning the nature and location of the civilization responsible for its creation. A "message" was conceived and etched on a plate (Fig. 1). The representations depict the nature and location of our civilization, designed for recognition by other civilizations at our level of development.

I have employed a reproduction of this plate in my biology classes as an exercise in reasoning and role-playing. The class was divided into small groups and told to study the plate and report on its content and meaning. Members of the group were instructed to pretend that they were the scientists of the discovering civilization entreated to interpret the meaning of the plate. These further details were given:

1. The scientists had before them the spacecraft for observation.
2. The craft and the plate were badly pitted after a long time in space.

Each group was to report its findings. Two questions were asked:

1. What do the various figures show?
2. What was the purpose of including these figures?

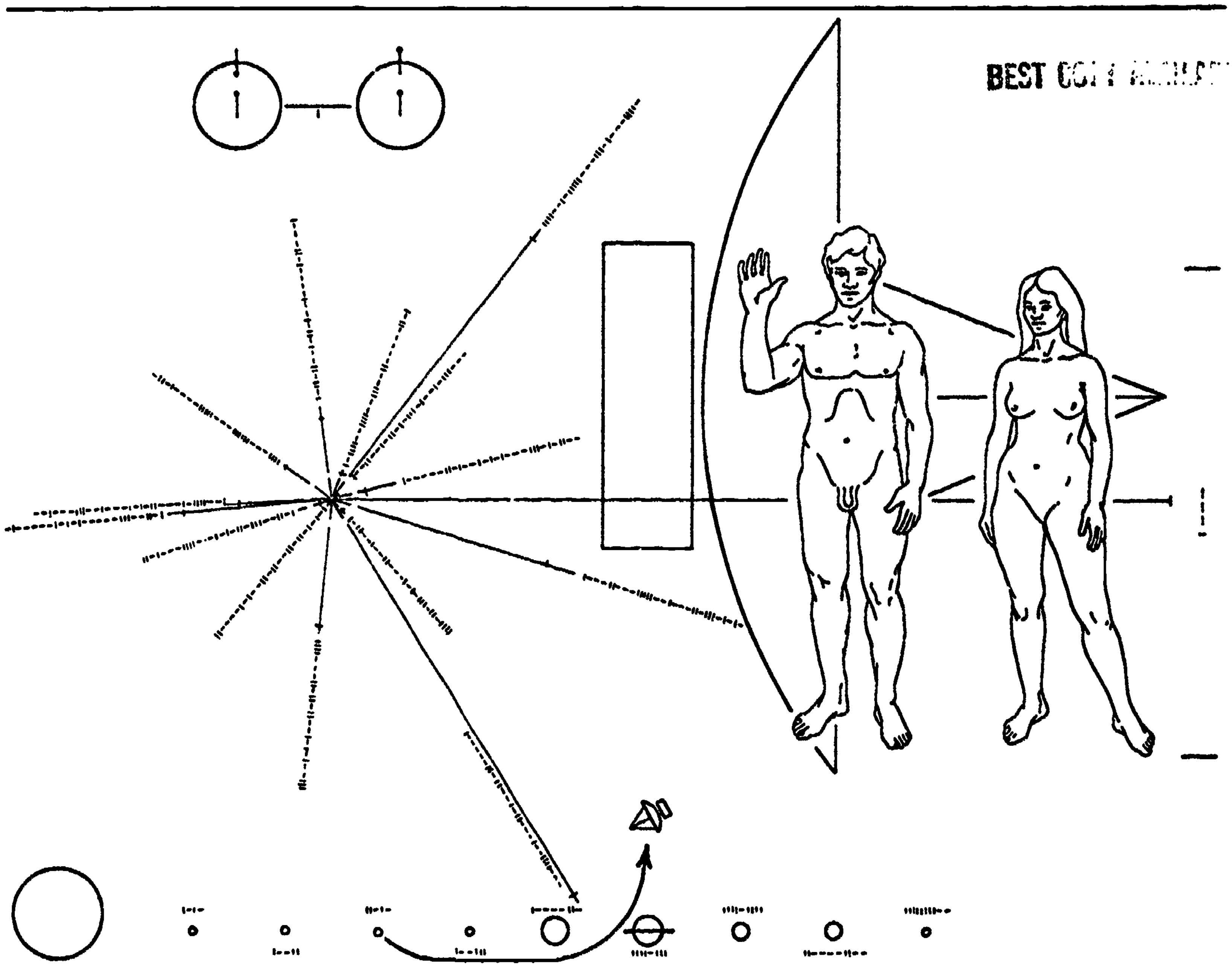

Fig. 1 Engraved Plate aboard Pioneer 10 as depicted by Sagan, Sagan, and Drake (1972). (Figure courtesy of Dr. Carl Sagan, Cornell University.)

Table 1.

Sixteen groups of students were involved in interpreting the figure on the Pioneer 10 plate. This table gives the figures, their meaning, and the number of correct responses.

FIGURE IN...	REPRESENTS	NO. GROUPS WITH CORRECT RESPONSES
Upper left	Hydrogen atom - a time measure	3
Center left	Time interval notations for the location of our solar system in space. The 14 lines represent time intervals corresponding to pulsars.	6
Bottom	Solar system and path of Pioneer 10.	14
Right Center	Humans superimposed over sketch of spacecraft to show relative size. Man with hand raised represents the "universal" friendly gesture.	14

After each group reported, an opportunity was given for interaction and discussion between the members of the entire class. The result was a classwide agreement on the meaning of the figures.

The response of the students was quite surprising, for they were able to interpret and give rational explanations for many of the figures on the plate, though the groups were unfamiliar with the reports carried in the popular press. Table 1 lists the figures, their meaning, and the number of responses that were generally accurate. There were 16 student groups.

After discussion, I introduced some additional questions which had not occurred to all the classes, such as:

1. Why are the man and woman not wearing clothes?

2. Why do you think scientists rejected the suggestion that the man and woman hold hands?

3. Do you think it is wise to "advertise" our location in the universe"

4. If you were given the assignment of devising a plate to be placed aboard a future spacecraft, describe how you would represent mankind and the world in which he lives.

The success of the exercise was due to a number of factors, the most important of which was the meaningfulness of the exercise to the students. Since the subject of space exploration is well known, the problem they were asked to solve was very real to them. Secondly, expressing oneself in a group situation in which role-playing (as the scientists) is a part, added to enjoyment and lively discourse.

This exercise and others like it can be useful in showing the logical processes which are a necessity in science. It can further show the group effort and cooperation encountered in almost all of today's scientific research. Whether as a beginning experience to set the stage for a course or as a refreshing change from other classroom activities, this exercise offers an opportunity for group effort in problem-solving involving current scientific thought.

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THE PROJECT ORIENTED LABORATORY AS AN EFFECTIVE TEACHING METHOD FOR NONSCIENCE MAJORS

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In the United States there are two principal types of introductory science courses. The first is the time honored study of a representative set of basic laws and theories of the science currently practiced and understood. The second is a survey course for nonscientists who can be assumed to be taking their last course in science. This type is also termed by many instructors as "the overview course."

Both types of coverage lack one major consideration, that of the needs and interest of the nonscientist. The development of the concept of the open laboratory was drawn from the many concepts and publications in modern educational methods the most notable being the experimenters who produced Summerhill, open classroom. This, coupled with a basic belief that our students were not learning to deal with science as it operates in our society and the basic realities of controversy in science and politics, caused us to design a course program that we feel has greatly improved the quality of our educational program.

The rationale behind our program includes the following principles. First, with the current information explosion in biology, no citizen can operate properly in our society without some background information on the current problems and their total implications in an ecologic system. Second, most students are not in school because of a desire to be there but rather from societal pressure. Therefore, societal needs are of tremendous importance in designing a course. Third, the traditional laboratory experience in biology is of questionable value to the nonscientist. Fourth, the traditional cookbook laboratory does not teach students how a scientist works on the forefront of research or how science is involved in current programs. Fifth, the students of today are looking more and more for involvement in education with the real world.

With this background the Project Oriented Laboratory was developed. It was designed primarily to provide students with a medium through which they could become involved with biology and current problems through research, application of existing data, political and community action concerning the quality of life. Prior to this charge a Traditional Classroom Laboratory system was used.

The following is a list of several points of which students are made aware concerning the course requirements.

1. Each student or group of students is required to select a project on the list provided, or preferably of their own design, and turn in a project design and contract to the instructor by the second week of the quarter. It is the responsibility of each student to live up to his contract. The first week is spent in teaching methods of design.

2. Each student will in turn in a mid-quarter report on the project.

3. Each student will turn in a final evaluation and report on the project.

4. Research advice, resources, guidance, etc. is provided by the instructor with maximum cooperation between different members of the science division and resource persons in the community.

5. Grades for the project are based on time spent on the project (about 40-50 hours for a ten week quarter), degree of completion of the project, student attitude toward the project, project design, and final report and success of the project.

There is no formal laboratory period assigned to the course. All teaching is done on an individual basis with large blocks of time being made available for students to contact the instructors. In addition, students are required to attend a weekly conference for one hour to discuss projects and solve problems that have evolved. The conferences are limited to 20 students with care being taken to keep discussion student oriented. To aid in this, individual students make reports to the conference on their project with other students evaluating and solving problems in projects. Students that are working on some project indirectly related to biology such as inservice work for some organization, prepare a short research paper on some biological aspect of their work.

The class is offered fall and spring quarter with a yearly enrollment of about 150 students. One instructor has primary responsibility for the course each quarter it is offered and three other instructors assist in an advisory capacity for projects. This is in addition to their full time load and comes out to about five to ten students each.

The only real change in materials needed to operate this type of a course was in the area of basic ecologic studies with special emphasis on water and soil related problems. In this regard we have purchased another tabletop model incubator for basic microbiological tests, four water testing kits (two for dissolved oxygen and two for more extensive testing), sedimentation cones, Jackson turbidity meter, and soil testing kits.

It is the belief of the instructors that the success of the course can be measured by the success of the projects completed. About 150 students start projects per year with a completion record of about 75-80%. Close to half of those completing projects do a very good job with more time spent than is required. Below are listed a few of the projects that have been completed as a result of our project oriented laboratory.

1. Ten students acquired a lease from the city of Vancouver on seven acres of undeveloped land north of our campus. They have developed a park on this land.

2. One student developed a strain of Drosophilia fruit flies resistant to DDT.

3. For the past three years students have operated a recycling organization, SCRAP (Students Council for Recycling and Abating Pollution). Currently we are in the process of construction of a permanent building to house this facility.

4. Our students have studied 12 major streams in the local area including bacterial studies, chemical analysis, sediment studies, animal and plant life investigations, and erosional studies. Copies of studies that point to environmental problems are sent to the proper authorities. Because of this policy, our students have been involved in political issues and other community problems.

5. We currently have a group of students working on a detailed land use and ownership map for the Washington side of the Columbia River gorge. Our students have also been involved in land use planning in our local community.

6. Some students have elected to work in health services, including:
   a. Well baby clinics
   b. School vaccination programs
   c. Food to needy individuals
   e. VD education programs

7. One of our students currently has a research paper in preparation for publication on his work with the productivity of Great Blue Herons.

8. Two areas in the Gifford Pinchot National Forest may well become part of the Wilderness system partially based on studies done and political action taken by our students.

9. Washington now has many unique laws that our students helped to shape by political involvement and active research.

The instructors that have worked with this course have had some problems. Some of these problems and possible solutions are listed below.

1. Students tend to delay until the last week all work on projects. This problem was fairly well solved by use of conference reports, mid-quarter reports, and project checklists kept by advisors and instructors.

2. Also some students seem to have trouble developing projects. We have found that it helps to solicit the cooperation of community groups, local government, conservation

groups, and other interested individuals for projects. We also keep a list of projects for students who have problems.

3. With students out in the community, differences with individuals in the community sometimes develop. It helps to provide the administration with a list of all projects being worked on for each quarter. Also it is important to stress to students the importance of working in the existing system.

We believe that the sharing of information through conferences gives each student a wide exposure to many areas of biology. Also, student evaluations have been of great value in developing the course around the interest of our students and in evaluating the success of the laboratory.

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ENVIRONMENTAL EDUCATION PROGRAMS IN THE NATIONAL PARK SERVICE: AN APPEAL TO REASON

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Environmental education is the key to our environmental problem education for adults of all ages and occupations and, of course, education for the young. A clear understanding of basic ecological principles and systems is necessary for anyone to make sound environmental decisions.

If we define environment simply as our total surroundings, then perhaps man's first education was environmental. What to eat and what not to eat, how to avoid being eaten, where to live all these were basic environmental decisions of early man. His adaptation to and basic understanding of the life around him and his physical surroundings were necessary for his survival. At least numerically now, there is no question that early man's basic environmental education has proved successful.

Today, at least, in the more highly developed nations, most men have lost their understanding of basic environmental dependence. For the majority, the environment good or bad is something taken for granted. To many inner city children milk is something that comes from a carton or a bottle (not a cow!); air is something that can be *seen* because it is dirty, and wildlife means rats in the alley or in the apartment.

Where people live and how people live, with each other and as part of the natural environment, these are the real gut issues of the environmental crisis. Without man there are no environmental crises – only natural systems at work.

Environmental education begins with environmental awareness. Many private organizations and public resource management agencies have developed fine environmental programs and curricula. One of these programs, NEED (National Environmental Education Development), has been developed and promoted by the National Park Service, U.S. Department of the Interior.

The National Park System contains a variety of natural and cultural treasures, many of which are representative of environmental quality. These areas provide opportunities for the development of basic understanding and appreciation of the interrelationships upon which our quality of life depends.

Environmental interpretation by the National Park Service emphasizes a "man-centered" approach, attempting to answer the question, "What does it mean to me?" The understanding of what *it* means to me, is the difference between approaching environmental problems through reason or through emotion.

The NEED Program seeks to develop appreciative and critical environmental awareness through an understanding of natural and cultural interactions as illustrated in areas administered by the National Park Service. This is a curriculum-integrated program using specially developed teaching materials. Eventually, NEED materials will be prepared for kindergarten through twelfth grade.

The NEED materials furnish a new way of looking at all subjects. They encourage awareness of the interrelatedness of all aspects and systems of the environment, cultural as well as natural.

NEED is organized in phases which correspond to the various stages of a student's growth and interest patterns. Phase I is developed for the elementary school level. It strives to help children become aware of the natural world and its processes through personal perception, observation, and differentiation. Appreciation of the environment is a main objective.

Phase II is designed for the middle grades or junior high school. Here the emphasis is on proper utilization of environmental resources, with introduction of concepts on man's use, misuse, and abuse of his environment. Concepts of care and correction of environmental problems are appropriate at this level.

Phase III is designed for the secondary grades, and its goal is the creation of a personal environmental ethic. All the aspects of responsible citizenship social studies, behavioral sciences, history, government, science all contribute toward the total environmental picture.

Originally formulated by the National Park Service, the National Environmental Study Area (NESA) program is now a cooperative venture of bureaus within the Department of the Interior, the Department of Health, Education, and Welfare's Office of Education, the National Education Association, and local educational communities. Curriculum materials have been developed by the National Park Service and participating schools.

An environmental study area can be anywhere — a beach, a marsh or pond, a field or forest, a park or playground. It can also be a town dump, the school grounds, an historic building, or a battleground. Currently I am working on developing teacher curriculum materials for the use of a shopping center as a NESA.

Some NESA's are primarily natural, exemplifying the natural elements and systems from which man is made and has developed his society and culture. Some NESA's are primarily cultural. Here the environment and the individual become an indivisible whole — a reality whose meaning for each person lies in his own involvement.

At Cape Cod National Seashore we offer the NEED and NESA programs, with five areas being designated as Environmental Study Areas. The NEED Program features a five-day overnight experience for grades five through eight. Classes stay at a former Coast Guard Station and are responsible for preparation of their meals and care of the facility. Thus the program becomes not only environmental education in content, but a total social learning-living together experience. Specific teacher aids have been developed for Cape Cod and are provided to participating schools. Teacher workshops are offered to provide use of resource material and suggest ways of adapting the area experience to the entire range of classroom curricula. Sensory perception is an excellent introduction to environmental awareness — for both teachers and students.

Now in its fourth year of operation at Cape Cod National Seashore, the NEED-NESA programs, operating throughout the school year, have included schools from Massachusetts, Connecticut, and Rhode Island. This coming school year, schools from New Hampshire and New York are scheduled. It is the goal of our program for schools to continue their NEED-NESA experience back home in their local communities. Many schools have developed their own environmental study area and related teaching aids.

Our objectives are to:

1. introduce students to their total environment — cultural and natural, past and present.

2. develop in them an understanding of how man is using his resources.

3. equip them to be responsible and active members of the world they are shaping and being shaped by.

In other words, the development of environmental attitudes and ethics. If today's students can develop environmental awareness and attitudes it should lessen the reaction to environmental crises with emotion rather than environmental reason. Our goal in environmental education should be to help the individual come to grips with his own world by arriving at his own personal environmental ethic. Such an ethic must be based on an understanding of earth's natural systems and the human systems man has devised and superimposed on nature. It must also grow out of a personal desire to participate in the total life processes of our planet. For who has the most to gain or to lose in the total environment of tomorrow than the child of today?

INFORMATION FOR CONTRIBUTORS

Correspondence: All correspondence should be directed to the Editors, *AIBS Education Review*, American Institute of Biological Sciences, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016.

Editorial Policy: The Editors will welcome manuscripts on biological education from administrators, faculty, students, and those outside academe who are engaged in educational pursuits. Articles describing research studies in biological education, new learning programs, and viewpoints stimulating dialogue in biological education are requested.

The usual length of feature articles is 3,000 words. Manuscripts must conform to the C.B.E. Style Manual. Illustrations are acceptable, but text length should be adjusted to accommodate them. The recommendations of reviewers will be considered for each manuscript submitted. The Editors reserve the right to edit manuscripts, but authors will have an opportunity to approve galleys.

Papers are accepted for publication on the condition that they are submitted solely to the *AIBS Education Review* and that they will not be reprinted or translated without the consent of the Editors.

Preparation of Manuscript: In the preparation of copy, manuscripts should be neatly typewritten in 57 character lines, double-spaced throughout, including references, tabular material, footnotes, etc., on one side only of 8½ x 11 inch white bond paper. No abstract is required. Please submit the original plus two additional copies. The author should retain a copy. A separate title page should be provided, and footnotes, figure descriptions, and tables should be typed on sheets separate from the text. At least one of the copies must be complete with figures, tables, and references. Please convert all weights and measures to the metric system.

Illustrations: Illustrations such as photographs, maps, line drawings, graphs, etc., should be submitted, unmounted, with the manuscript. Only black and white illustrations will be accepted. Number figures consecutively and identify on the reverse side. Glossy photographs are required and must be at least 4 x 5 inches but not larger than 8½ x 11 inches. Originals of drawings are requested. Generally, drawings larger than 8½ x 11 inches are not acceptable. Lettering on all illustrations must be sufficiently large to allow reduction to a single column. Figure captions for each illustration should be typed on a separate page and accompany the illustration.

References: In the text, references to literature citations should be designated by the author's name and year of publication in parentheses. If there are more than two authors, only the senior author's name should be listed in the text with the abbreviation "et al.," for example: (Smith et al. 1965). Only published references should be given in the References section, and each should conform in style to the name-and-year system of the C.B.E. Style Manual.

ABSTRACTS — FROM THE 24th ANNUAL AIBS MEETING, AMHERST, MASSACHUSETTS

Graduate Education: Present Problems and Future Prospects

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Abstract of Keynote Talk
AIBS Symposium
18 June 1973

The present state of graduate education in the biological sciences is somewhat cloudy. During the past decade there has been a great proliferation in the number of institutions offering graduate programs. These programs, like some of the established ones, vary extensively in both scope and quality. Reduced federal and state budgets, a poor job market, and the clamor for accountability may bring about more collaboration among neighboring institutions, the retrenchment of some programs, and the elimination of others. Biologists sorely need, but probably will not establish, some mechanism of self-policing. If quality control and decisions on which programs are to be eliminated are left up to state coordinating boards, wisdom and logic may not always prevail. Professional accreditation is not the answer. Presently, programs vary from the very narrow (e.g., dental anatomy) to the very broad (e.g., animal sciences) and from the self-contained within a department to the truly multidisciplinary.

Prospects for continued high levels of funding and hence employment possibilities appear to be best in the areas of cellular-molecular biology (primarily as it relates to disease) and in environmental biology (especially that with a biomathematical or socially relevant thrust). Most graduate training programs suffer from their isolation from the social sciences and humanistic disciplines.

The probability for federal funding to return to the "easy money" days of the 1950's and 1960's is remote indeed. Such monies as are forthcoming will most likely be in goal-oriented areas. It is difficult for a generation of scientists brought up in the post-Sputnik era to accept the fact that we may only now be returning to a period of "normalcy."

As yet, the Doctor of Arts degree has not found wide acceptance either among graduate institutions or among potential employers. The degree does offer a solution to the problems of staffing two-year and some four-year institutions with highly qualified instructors.

Decremental Planning and Dysfunctional Attitudes

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Presented in the symposium, "Graduate Education: Current Problems and Future Prospects," 18 June 1973.

The common patterns of incremental planning have run into difficulties arising from the dollar crunch, declining enrollments, and the poor marketability of doctoral recipients. Decremental planning is already a common practice on many campuses. This requires a significant upgrading in our sense of priorities and an awareness that many programs will have to be curtailed or eliminated to preserve or foster others. Since individuals and bureaucracies frequently yearn for the preservation of the status quo, dysfunctional attitudes arise on all sides. Graduate faculties appear not to be immune to this phenomenon.

The source of dysfunctional attitudes can be seen in the pursuit of many questions. What are the best ways to reduce a departmental budget by 5, 10, or 15 percent? How do you know when to cut across-the-board and when to prune selectively? What is the lowest critical mass for effective operation in a program? How do you enthusiastically encourage students to pursue their studies when unemployment is their likely reward? How do you balance teaching, research, and service while reducing personnel? These are questions of significance in decremental planning. Individuals who are unable or unwilling to deal with them and take refuge in a "business as usual" stance are contributing dysfunctional attitudes leading to the further impairment and decrementing of their department's programs.

LETTER TO THE EDITOR

It takes effort and imagination in these days of restricted budgets to keep fresh ideas flowing into a department; yet, if the department is not to stagnate in a miasma of self-content and provincialism this flow of ideas must continue unabated. This letter is to share our experience with a program of renewal and refreshment that requires more ideas than money to succeed. We call it our Shot-in-the-Arm Program. It has lived up to its name.

Under this program, we invite experts to the campus to deal with special areas where expertise can unlock a whole train of self-improvement and make possible new ventures formerly inaccessible for want of this expertise. A couple of examples will show best how the program operates.

Despite our best efforts, we needed new ideas on how to handle the biology component of our library. We sought out a young biologist-librarian who had distinguished himself by developing an exemplary program for effective use of the library on his own campus. At our request, he evaluated the biology book collection in the library, prepared a list of journals that might well be dropped and listed others that would improve the college holdings. He suggested better ways for the department to develop its annual list of books recommended for purchase. He recommended various steps the department might take to encourage students to make better use of the library. His discussions with the professional library staff and the biology staff, together and separately, not only stimulated both to better performance, but established new, more active cooperative ventures. As a consequence of his visit, a librarian has been assigned to the department for liaison. Her enthusiasm for her new role is demonstrated by the fact that she is auditing a beginning biology course this fall.

Sometimes the visitor worked directly with a faculty member and his class, opening new vistas in the subject matter area. The genetics class obtained the services of an expert in the genetics of photosynthesis. He spent two vigorous days on the campus giving lectures on extranuclear inheritance and setting up laboratory experiments with the students so that they could study plastid inheritance in *Chlorella*. Typical of those who dealt with subject matter, he left cultures, media, ideas for independent study, references, new techniques, and an enormously stimulated faculty member and class.

These will serve as examples, but the contributions of others who visited during the two-year period were no less exciting. The assistant to the director of an important botanic garden went over the operation of the college greenhouse and advised on how it might be improved. A pioneer in the field of audio-tutorial education worked with a member of the staff who was developing teaching modules for her class. A visiting radiation biologist worked with the whole department to introduce radiation techniques where appropriate in the department program. A plant physiologist and an animal physiologist worked with faculty members to add new zest to the program. The legacy of ideas left by these consultants will invigorate the department for a long time.

Few colleges could pay for such a program if compensation were proportional to the value received. Fortunately, those one would hope to invite are dedicated teachers who take great pleasure in sharing their enthusiasm and ideas with others. They have been willing to come for expenses and modest honoraria. The most important reward for a consultant is the feeling that he did something worthwhile that he really made a difference. It is only fair that the consultants have every opportunity to make a significant contribution. There should be careful preparation for their visits and their ideas should be thoughtfully considered. Most want no part of a ceremonial visit, but would prefer to be used to the utmost while they are on campus.

Only $500 was contributed to the program by the college. The AEC supported the visit of the radiation biologist, but the rest was paid for by gifts, only one of which exceeded $100. The biggest contribution, of course, was made by the turned-on consultants who were so generous in sharing their ideas and enthusiasm.

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HELP NEEDED TO ACT ON IDEAS FROM THE ANNUAL MEETING

Discussions at the last AIBS annual meeting at the University of Massachusetts produced many more ideas than our office staff has either the time or the expertise to explore. Therefore, we are calling on any of our readers who have the time and inclination to assist us.

Several students expressed a need for better information on how to select a graduate school. Graduate students or faculty who have ideas and recent experience in this area might consider preparing a manuscript for publication in the *Review* or preparing the text for a brochure to be distributed to interested students. How to look for a job and how to plan a career were other topics of interest to students. Manuscripts on these topics might be used in communications with student chapters.

The results of our Manpower Survey show that only 1 percent of respondents are members of ethnic minorities and that 18 percent are women. Consequently, insufficient information about the status of women and minority members was derived from the study.

Related to the problem of insufficient information on the status of women and minorities is the need for description of experience with workable affirmative action programs. If you have evidence to demonstrate successful application of your ideas, write us a short note. Your experience might be very useful responding to inquiries we receive in the Education Division, or perhaps would be of sufficient general interest to justify publication.

This publication is a medium of exchange among biologists with common interests and problems in their pursuit of excellence in biological education. The extent to which the *Review* reflects your concerns and serves to publicize creative and constructive solutions to problems depends on you. Please share your ideas with us.

THE 1974 ASIA FOUNDATION GRANTS

The Asia Foundation is continuing its support of biologists who are pursuing pre- or postdoctoral graduate study in the United States and who intend to return to their home country upon completion of their work. Nationals from the following countries are eligible for awards under the program: Afghanistan, Bangladesh, Burma, China, Hong Kong, India, Indonesia, Japan, the Khmer Republic (Cambodia), Korea, Laos, Malaysia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka (Ceylon), Thailand, and Viet Nam.

Those qualifying on the above criteria are eligible to apply for the following:

Grants-in-Aid

The Asia Foundation has authorized the AIBS to offer grants-in-aid of up to $200 each to qualified Asian biologists or scientists in closely related fields for the purpose of assisting them to complete research projects. The grants may be used to purchase materials, literature, or to obtain clerical service for the preparation of a thesis or final report.

Travel Awards

The Asia Foundation has authorized the AIBS to offer grants of up to $150 each for travel or *per diem* expenses to enable Asian biologists who are visting the United States to conduct research or pursue graduate studies to attend the 1974 Annual AIBS Meeting at Arizona State University, Tempe, Arizona, 16-21 June 1974.

Asia Foundation Award

The Asia Foundation has established the Asia Foundation Award for outstanding research published during 1972 or 1973. Papers may be submitted by the author, his mentor, or any co-worker in the fields of biology, agriculture, natural resources and basic (nonclinical) medical science. Only single author papers will be considered. The award, to be presented at the AIBS Annual Meeting, carries an honorarium of $400, plus up to $150 to cover travel expenses. In the event the recipient has already returned to his home country, the honorarium award will be made in absentia.

Procedures:

Grants-in-Aid and Travel Awards

Application forms are available from: AIBS Asia Foundation Program, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016. If the applicant is a student, the need for such a grant must be established by the student's major professor or department head. All applicants must explain the limitations of their present financial aid and must state an intent and expected date of return to Asia in the near future. The university or organization affiliation in the home country, an explanation of source of present financial support, and a brief paragraph explaining present research should be included in the application. Deadline for receipt of applications is 1 March 1974; notification of action will be made by 1 April 1974.

Asia Foundation Award

No application form is required. Five (5) copies of the paper should be submitted to AIBS Asia Foundation Program at the address given above. The paper should be accompanied by a brief statement indicating the (1) author's U.S. address; (2) university or organization affiliation in his home country; (3) social security number; and (4) expected date of return to Asia. Final date for receipt of papers is 1 March 74; the recipient will be notified on or about 1 April 74.

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